Measuring the Meridional Overturning Circulation with Satellite Altimetry and Gravimetry

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The Thermohaline Circulation (THC) is the density-driven water circulation, especially in the N. Atlantic. The Meridional Overturning Circulation (MOC) refers to the sum of the THC and the wind-driven, mostly upper ocean circulation. The THC and the MOC are related to climate in their ability to carry heat poleward, the THC with longer time scales than the wind-driven component. Relations between high northern latitude ice melting and sudden slowdown or shutdown of the THC have been discussed in the literature. Measuring the THC, determining whether or not it is slowing down, are important issues in climate discussions.

Recently, Cromwell et al (2007) proposed a method to measure the THC indirectly by measuring the MOC, using a combination of satellite altimetry (SSH) and GRACE-like time varying gravimetry (ocean bottom pressure, OBP). They argue that time changes in the spatial gradients of sea surface height and ocean bottom pressure yield the total (barotropic+baroclinic) transport of the MOC. They take the idea one step further by using the POCM numerical ocean model to simulate the transport and attempt to extract it from SSH and OBP alone. They compute geostrophic velocities from 4 grids point (~0.4 degree each) at the eastern and western ends of a zonal section, as well as Empirical Orthogonal Functions (large scale) of the fields. They recognize that the simulation does not apply to GRACE itself, but to some future higher resolution Gravity field measuring mission.

A crucial problem with this approach relative to spaceborne gravity measurements is that much of the flow in the MOC is concentrated in narrow western boundaries. This is true both of the wind-driven component (the Gulf Stream) and of the deep undercurrent flowing sourthward. Thus, understanding the extent to which these data alone can constrain the MOC is crucial.

Here we extend their work in two directions. First, we reproduce their results using a different high resolution model, ECCO2 (http://ecco.org). Next, we apply GRACE and foreseeable GRACE-2 spatial resolutions to determine how well the MOC can be determined. Finally, we ask what additional data types should be combined with the spaceborne data, and in what optimal manner, to perform this estimate.

Reference.

D. Cromwell, A. G. P. Shaw, P. Challenor, R. Houseago-Stokes, and R. Tokmakian. Towards measuring the meridional overturning circulation from space. OCEAN SCIENCE 3 (2), 223-228. 2007.